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DEVELOPMENT OF CENTAUR

A COMPUTERIZED WAR GAME

PART I

GENERAL CONSIDERATIONS

U.S. ARMY STRATEGY AND TACTICS ANALYSIS GROUP

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STAGTEN 62121
DECEMBER 1962

FOREWORD

A primary task of the U. S. Army Strategy and Tactics Analysis Group (STAG) is to develop a computerized war game for use in testing land-combat operational plans for any theater in the world. This extremely complex task has been divided into several phases, first of which is the development of an experimental or prototype version of the game, called CENTAUR

STAG presents herein the first portion of a two-part discussion of preliminary considerations in the development of a computerized war game. This part of the discussion is concerned with the conceptual and organizational framework within which CENTAUR has been developed. The second part, to be published in the near future, will deal with the problems involved in adapting machine-computation techniques to execution of the mathematical model.

When the CENTAUR game has been tested and debugged, a full documentation of the model and its constituent submodels will be published.

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ABSTRACT

This paper describes the basic concepts underlying the development of CENTAUR, an experimental methematical model for a computerized war game to be used in testing land-combat operational plans at division level CENTAUR is a two sided, free play, man-computer simulation The game is played by two opposing forces, Red and Blue, each of which is free to make tactical decisions which are not revealed to the other

The level of resolution appropriate for a war game is shown to depend upon the amount of detail necessary to achieve the game objectives The desired level of resolution is achieved through judicious choice of three elements the simulation element and the units of time and space The relationships among these elements are discussed and the selection of the company as the simulation element for CENTAUR is explained Actions at the company level of command and below are planned by the players but simulated by the computer The players can intervene to change their orders or issue new orders during the play of the game

The company-level actions simulated by the CENTAUR model are surveillance, movement, fire, reception of fire, supply, replacement, support, and communication of messages Each of these actions is represented by a submodel, and operation of the submodels is controlled by an Executive Program The nature of the operations performed by each of the submodels is briefly described, as is the procedure for human intervention in the computerized game.

Consideration is also given to the organization of the staff for model development The CENTAUR submodels were constructed by a number of analytical teams, each working unilaterally in its own functional area Responsibility for coordinating the team efforts and maintaining a consistent level of sophistication in the over-all model was vested in a control group, which exercised its influence through its control over the Executive Program, the interfacing parameters (submodel inputs and outputs), and the game files

1. INTRODUCTION

War Gaming is an ancient art. Even in Homeric times, some form of chess (the surviving patriarch of war games) was used to bring the excitement of the battlefield into tent or hall, to while away the tedium of the long intervals between campaigns, and to sharpen the warrior's wits and ripen his judgement. [1] Throughout history the war game, while changing in outward form to comply with the fashions, political organization, and military conditions of the time, has continued uninterruptedly to exert its fascination and to aid commanders in considering the consequences of alternative courses of action. Today, new-furbished with operational research techniques and high speed digital computers, the war game has become a valuable tool in the hands of military analysts and planners.

1.1 Operational War Games

An accepted military definition of war gaming is as follows:

> War Gaming is a simulation technique employing a representation of a military operation, which is conducted according to rules and uses data designed to depict an actual or assumed real life situation, for purposes of examining operational tactics and strategies, of providing training, or of research

War games differ in some respects according to the purpose for which they are played The operational games, designed to test military plans, deal with current organizations, equipment, and tactics. The methods, rules, and procedures used tend to be more rigid than those employed in either of the other types of games, and usually involve somewhat finer resolution. The objective of training games is to provide commanders and staff officers with an approximation of actual experience by leading the players through as many decision making processes as possible. Research games are played in order to analyze or evaluate proposed concepts, organizations, equipment, or tactics. The inputs, since they are concerned with matters still in the conceptual stage, are necessarily less factual, more speculative, than those available for the other types of games. They should, however, be as precise as possible. Results of the research games set the pattern for future tests, eliminate obvious errors, and minimize the number of solutions to be considered in the refinement of concepts. [2]

This discussion is concerned with the first of these types of war games -- operational war gaming.

Operational war gaming has probably been used most extensively by the Germans. For better than a century before World War I, war games enjoyed high repute in German military circles as training and planning devices. When, after Versailles, the size and activities of the German military establishment were severely restricted, the German General Staff resorted to war gaming as the nearest equivalent to large scale military maneuvers. The resulting war games were of very high quality. Operational war games were conducted on the invasion of Czechoslovakia, the incursion into France and the Lowlands through the Ardennes, and the invasion of the Ukraine.

The General Staff also war gamed the invasion of England in order to pinpoint the numerous technical difficulties that would have to be surmounted before a Channel crossing could be attempted. [3]

1.2 Computerized War Gaming

The German operational war games were manual or hand played war games in which all decisions and status assessments were made by the players and the controllers. The principal objection of military planners to this type of game is the tedious and time consuming nature of the routine decisions and computational tasks involved. The preparation, play, and analysis of a single game of this kind may require months or even years to complete. Time requirements of such magnitude strictly limit the practical usefulness of manual games. Thus, war gamers were strongly motivated to exploit the computational capabilities of electronic computing devices. If a high speed digital computer could be incorporated into the game to make routine decisions and assessment computations, the drawback of excessive time requirements could be eliminated.

During the early part of this century, many attempts were made by scientists to reduce at least some aspects of conflict to quantitative form -- a requisite for machine computation. Notable among these were the efforts of Lanchester [4] and Von Neumann, [5] which provide many of the concepts and techniques required to permit the utilization of computers in gaming. An essential feature of all this work is the description of a complex situation in such terms that the consequences of a decision do not depend solely upon the actions of the decision maker, but upon those of his opponent, as well.

If the situation can be so described, and if the decision making process can be defined and its results understood, it is possible to construct a mathematical model to depict the conflict involved. In a war game, the most important parameters of combat are considered in their logical sequence. A model of a complex situation may be constructed from a number of submodels, each of which is a functional part of the mathematical representation of the problem. The model and its constituent submodels then form the computer program on which the structure of the war game is built.

The representation of battlefield activities by a model in a computerized war game is a simulation -- i. e., an imitation of the behavior of an actual phenomenon by another device that is easier to construct or study The machine simulation may or may not provide for the intervention of human players. When there are no players, the decisions at all command levels and the assessment computations are performed by the computer for a specific time or until a specific event occurs. When there are players (man-computer simulation), the players make the decisions above a given command level; decisions below that level of command, and all assessment computations, are relegated to the computer.

Even though the computerized portion of a game lacks the realism of human-injected decisions, it need not be entirely deterministic Obviously, the types of decisions most suitable for machine simulation are those that are most strongly determined by objective events -- i. e., those in which, given that such and such a situation exists, there is an extremely high probability that a certain decision would be made. Even the highest probability, however, is not a certainty; and modern statistical techniques provide a means for preserving the small but ineradicable, and sometimes crucial, element of chance in the machine simulation. This is done by performing probability tests at appropriate junctures in the game to ascertain whether a highly probable event is to be considered as having occurred or not having occurred.

The man-computer type of simulation offers many advantages in the testing of operational plans. The computer handles the routine decisions and assessment computations, thus freeing the players to make decisions consistent with those they would face in a real battlefield situation -- decisions in which military judgment and experience are important factors.

2. DEVELOPMENT OF A LAND-COMBAT WAR GAME

2.1 Phasing

One of the major tasks assigned to the United States Army Strategy and Tactics Analysis Group (STAG) is the development of an operational war game for use in Army campaign and contingency planning. The requirement is for a man-computer simulation of the battlefield environment, designed to test the suitability of land combat operational plans for any theater in the world. This is a highly ambitious project -- construction of perhaps the most complex and comprehensive war-gaming model ever attempted. For this reason, it has been broken down into subtasks, phased as follows:

PHASE I: Develop an experimental model of a division-level game, to be used by STAG's personnel in studying such problems as game resolution, the effect of variable game parameters, the programming system, game control, and the realism of the simulation and display.

PHASE II: Develop an operational division-level game to test division operational plans against specific objectives established by the division staffs whose plans are being tested. This game will provide STAG with pertinent information about the aggregation of combat units.

PHASE III: Develop an operational theater-level game by expanding the division-level game to the field army level and then to the theater army level. Information gained from the play of the division-level game will be utilized in this phase.

Work is presently in the first phase -- development of the experimental model, which is called CENTAUR. Since both this phase and the second are concerned with the gaming of division operational plans, an initial step was to determine those attributes of the plan that should be tested in order to study the majority of the problems confronting a division commander. It was reasonable to assume that these problems would arise in the areas of replacement, surveillance, tactics, organization, weapons, communications, and logistics. Our goal, therefore, was realistic simulation of activities in these problem areas.

2.2 Concepts Underlying Construction of the CENTAUR Model

2.2.1 Level of Resolution

At the outset of the development of the CENTAUR model, certain conceptual decisions had to be made. Primary among these was determination of the level of resolution that would provide sufficient data for adequate simulation of combat situations without creating an unwieldy mass of unnecessarily detailed information.

In determining the optimum level of resolution, the problem is analyzed and reduced to its simplest terms or elements. Most problems that lend themselves to simulation can be resolved into three basic elements the simulation element and the units of time and space.

2.2.1.1 Simulation Element

The simulation element is selected from among the physical entities whose actions and interactions create the situation that is being simulated. For instance, in gaming rail transportation in the United States, the classes of entities to be considered might include individual box cars, trains of stipulated length, and regional areas. In a simulation of military airport operations, the entities might be individual aircraft, squadrons, and wings. In gaming land combat, the entities of interest are the various levels of command.

Selection of the physical entity most suitable for use as the simulation element is based on detailed studies of the objectives of the simulation, to assure that the entity chosen is appropriate to the detail required to solve the problem. Only rarely is it possible to rely on mathematical techniques to make this determination. In most cases, the subjective reasoning of the analyst must play a decisive part.

It is apparent that the most realistic simulation of land-combat action would be one based on the individual actions of individual soldiers. Such a simulation would, however, involve a mass of detail far beyond the capabilities of even the most elaborate computer. It was therefore necessary to select an organizational unit at a higher level in the command structure. Our aim was to select, from among the possible elements, the largest one that could be considered generally homogeneous in its battlefield actions and that would provide a level of simulation consistent with the game purpose. Analysis indicated that the company is the organizational element that best satisfies these conditions. Choice of the company as the simulation element was based on the following reasoning.

> The three smallest elements in the military organizational hierarchy -- the individual soldier with his weapon, the squad, and the platoon -- can readily be aggregated for simulation purposes. As a rule, all soldiers in a given squad are usually engaged in the same type of battlefield activities, as are all squads in a given platoon. The next larger element, the company, may not be a completely homogeneous unit; but in combat, and for a given time period, it may reasonably be so considered. Because the subordinate elements of a company operate in a limited area, they are all affected in more or less the same way by enemy action and have the same effect on the enemy. Consequently, a simplifying assumption of homogeneity of action seems justified.
>
> Battalions and larger elements do not meet the criterion of homogeneity of action. One company of a battalion may be occupied by a type of action quite different from that engaging other companies of the same battalion. Therefore, the company appears to be the largest element that can be used to obtain an acceptable degree of realism in the division-level combat simulation without exceeding the storage capacity of the computer.

The combat units being simulated in CENTAUR are infantry and tank companies, cavalry troops, and artillery battalions. These will hereafter be referred to as "primary elements." Establishment of the primary elements at this level does not signify that the simulation is restricted to the present Table of Organization and Equipment of a U. S. Army company. Since the composition of the primary element is dependent on the initial input, any combination of personnel and weapon strengths that is appropriate to the company level of command can be input into the game.

2.2.1.2 Time and Space

A war game can be described as essentially a sequence of decisions, events, and assessments. There are two possible ways of sequencing the games: time-interval sequencing and critical-event sequencing. Time-interval sequencing consists of arrangements in a series of time steps, each taking into account all that occurred in the preceding time interval. Sequencing in the order of critical events is a method which has proved adaptable to air and naval warfare, but is not altogether satisfactory for ground combat. Scheduling of critical events on the battlefield is extremely difficult due to the wide variance in the events that may occur Therefore, time-interval sequencing will be used in the ground combat model being developed by STAG.

Like the simulation element, the other two elements -- time and space -- must be so selected as to be appropriate to the required detail of the simulation. It is interesting to note that the selection of the simulation element and either one of the other two elements fixes the third element.* For example, if an infantry company is the unit of calculation and a space element of 20 kilometers is selected, the time interval will be the time required for an infantry company to travel 20 kilometers. Consequently, in developing a model, it is logical to select the one of the two elements that is least subject to variation. In CENTAUR, this is time, because the space element is affected by the commander's disposition of his transportation capabilities. In the initial trials of the CENTAUR model, the time intervals will be of 15-minute duration.

2.2.2 Structure of the Game

Consideration was next given to the general game structure, including such items as the type of play and the organization of the opposing forces. CENTAUR is a two sided, free play, closed, man-computer simulation. This means that the game is played by two opposing forces, the Red and the Blue, each free to make tactical decisions which are not revealed to the other. The organization of both player groups is similar to the command structure of a division, from the battalion headquarters through the division headquarters.

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* In an annex to FAME, A War Game for Testing Division Organizations (U), ORO-T-383, Paul F. Dunn, has discussed the problems of resolution and the necessity for internal consistency in the space and time units in a ground combat simulation. It was shown that an arbitrary criterion for space and time aggregation of weapons effects can be used to infer consistent units of time and space.

Tactical decisions made by the players during the game are communicated to the simulation element by means of input orders. As indicated above, the actions of company-level units are simulated by the computer. Plans for these actions are controlled by the player groups. The activities of other combat support elements and administrative units are represented by simulating the effect of their support on the actions of the combat units.

2.3 Configuration of the Model

The next step was to develop a list of the basic actions of each company which must be simulated by the computer in order to represent adequately the activities of the companies in a combat situation. The list of basic actions is as follows:

1) Survey the area of operation
2) Fire
3) Move
4) Receive fire
5) Request and receive supplies
6) Request and receive replacements
7) Request and receive tactical support
8) Receive and transmit messages.

These classes of actions indicated the functional areas that must be studied in order to develop the model. The functional areas in CENTAUR are represented by the submodels, which are integrated into the model by an Executive Program.

2.3.1 Executive Program

Chart I is a functional representation of the Executive Program and Chart II is a schema of its operation, presenting a fictitious but reasonable representation of the relationship of the Program and the inputs, file areas, and internal operating submodels. The initial input information -- i.e., the information from the Division Operation Orders -- is input into the game and filed in the Unit File Area, as shown on the left of the schema. Each primary element (Red or Blue Company) played in the game has a file area for storing pertinent information about the company, such as location, personnel and weapon strength, supply status, mission, etc. Information required for sub-model operation, on such subjects as terrain, weather, and obstacles in the area of operations, is placed in the Environment File.

When all requisite information on the primary elements and the environment has been input into the computer, the play of the man-computer war game can begin. The time is t_o -- the beginning of the first time interval. The game director displays the situation to the Red and Blue commanders separately and queries whether it is correct according to the player orders. When the situation has been approved by both player groups, the computer begins operation.

2.3.2 Surveillance Submodel

The Executive Program first brings the Surveillance Submodel into the computing area and then brings in each Primary Element File in turn for updating. The Surveillance Submodel obtains from the

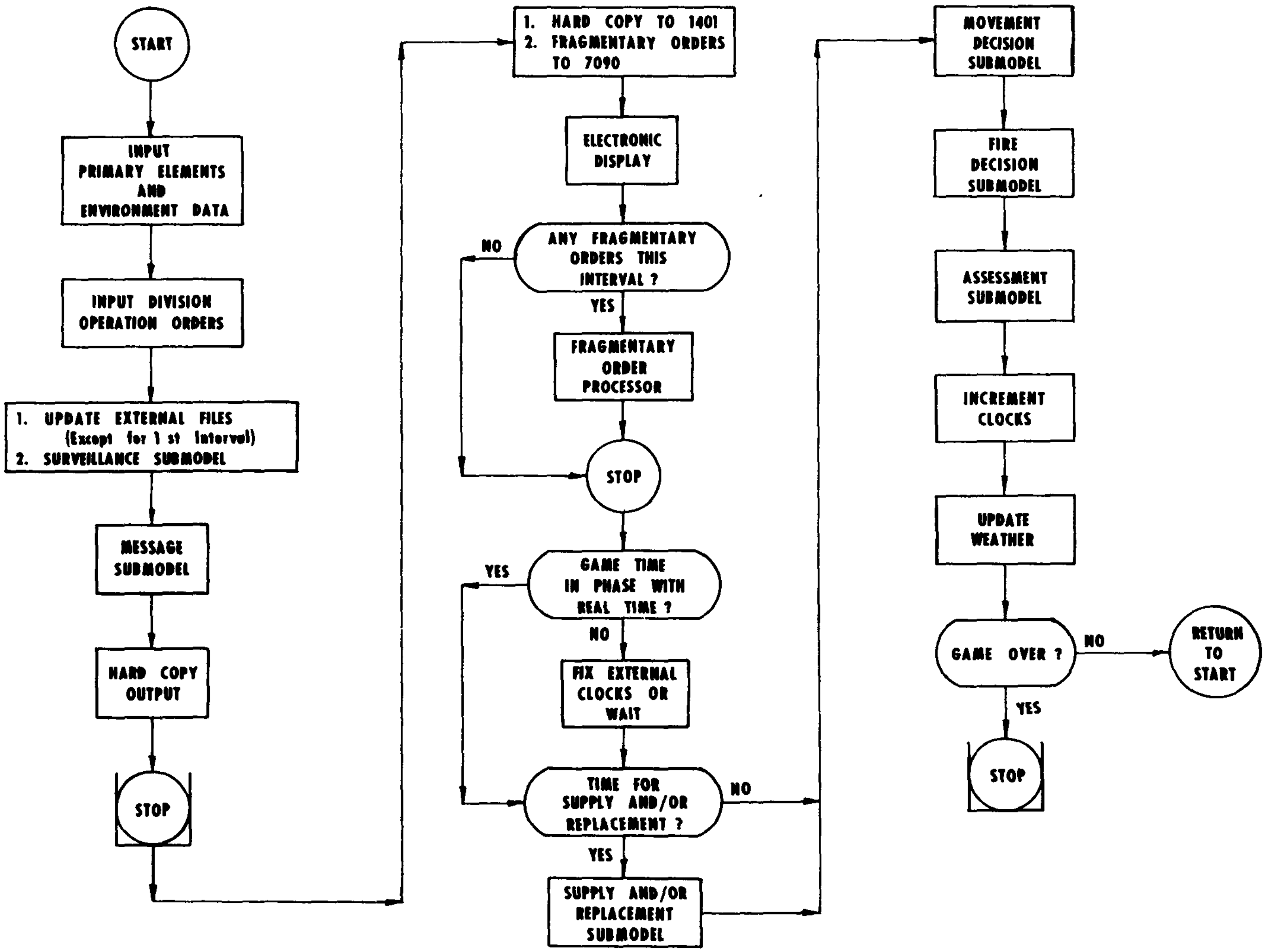

CHART I
FUNCTIONAL REPRESENTATION OF EXECUTIVE PROGRAM

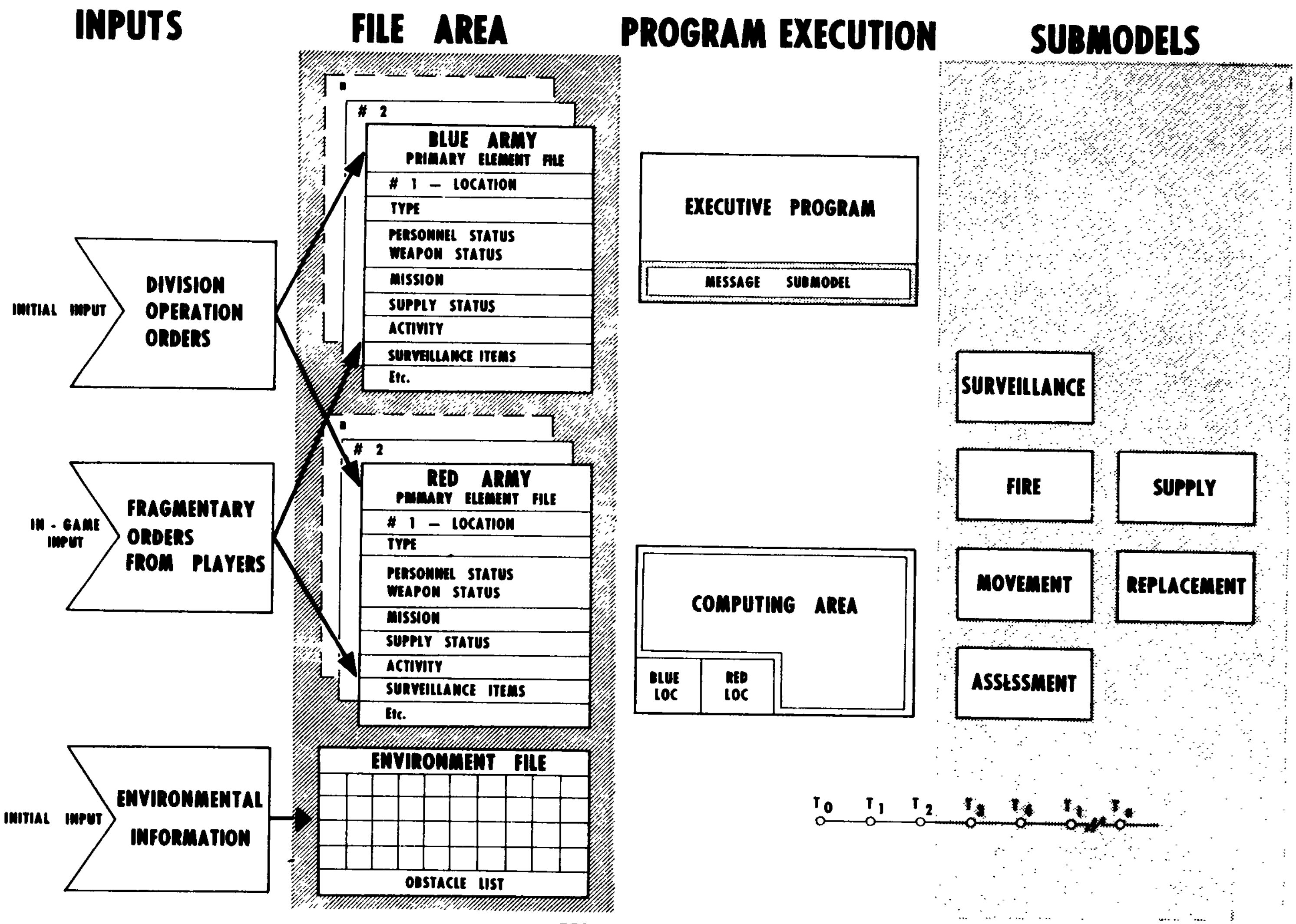

CHART II
SCHEMA OF THE CENTAUR MODEL

Environment File the needed terrain and weather information and calculates which enemy units each primary element can observe. This is done by determining the area that the primary element can possibly have under observation, and then performing a series of probability calculations to decide whether the primary element actually does observe the enemy unit or units within its area of observation. If the probability test indicates that the existence of an opposing unit is observed, further probability tests are conducted to establish the amount of information the primary element can obtain about the opposing unit's location, activity, size, and type.

In connection with the construction of the Surveillance Submodel, STAG has developed a new parametric method of terrain representation for play of line of sight. Originally, it was planned to use slope as the controlling parameter in playing line of sight, but investigation failed to establish any significant degree of correlation between expected values of slope and line-of-sight probability distributions. The new method is based on a demonstrable relationship between the natural frequency of occurrence of obscuring peaks and line-of-sight probability distributions. It has been described in detail in an earlier STAG publication.[6]

2.3.3 Movement Submodel

When the surveillance information has been updated for all primary elements, the Executive Program removes the Surveillance Submodel from the computing area and brings in the Movement Submodel. The Movement Submodel makes a movement decision for each primary element in turn, determining when, and at what rate, the element will move. The parameters used in arriving at the movement decision are such factors as the mission of the element, surveillance information, and element situation. For example, an element with an attack mission will usually move while one with a defense mission will usually remain in place. The movement decisions are posted in the Primary Element Files.

2.3.4 Fire Submodel

When each Primary Element File has been posted, the Executive Program removes the Movement Submodel from the computing area and brings in the Fire Submodel. Using the surveillance information, the Fire Submodel makes a fire decision for each primary element in turn. The fire decision determines whether or not the element will fire, and, if it will, what weapons to fire and at what rate. The decision is made in a probabalistic manner, using such parameters as range, type of target, threat of target, and mission. The resultant information is posted in the Primary Element File.

Artillery primary elements constitute a special case. When a primary element other than artillery locates a target, the information is automatically posted in the file for the artillery element in direct support. Consequently, in relation to this particular target, a fire decision is made not only for the primary element that located it but also for the supporting artillery element. This provision simulates the fire support of artillery on targets of opportunity. If a direct-support artillery unit receives more targets than the maximum at which it is capable of firing during a time interval, the targets posted after the maximum is reached are referred to reinforcing and general-support artillery units. The nature of the target is also a factor that may cause its referral to a larger-capability artillery unit.

2.3.5 Assessment Submodel

Up to this point, operation of the computer has not caused any accumulation of game time -- i.e., it is still time t_o, the beginning of the first time interval. However, now that the fire and movement decisions for the primary elements have been amassed, the computer is in a position to assess the results and interactions of these decisions. The Executive Program, after removing the Fire Submodel from the computing area, brings in the Assessment Submodel to assess the effect on each primary element of both its own decisions and those of opposing primary elements. This submodel must determine the amount of damage sustained by any units located in the fire-concentration areas of the elements that have made a decision to fire, and must compute the new locations of the elements that have made a decision to move. The move decision is not, however, the sole parameter determining the new location. If a moving unit is fired upon, the Assessment Submodel must cut back the movement rate in proportion to the amount of fire received.

During the assessment operation, game time accumulates by the duration of one time interval. The Assessment Submodel determines what happens to each primary element during the time interval and posts, in the Primary Element File, the new data on personnel strength, weapons strength, location, supply status, etc., for each element at the end of the time interval. When this new history has been posted, the Executive Program can swing back to the Surveillance Submodel to start a second cycle representing events occurring in the second time interval.

2.3.6 Supply and Replacement Submodels

In the CENTAUR schema (Chart II), the Supply and Replacement Submodels have been placed far to the right of the computing area to indicate that they do not, like the other submodels, function during each time interval, but only at some multiple of the time interval. The Supply Submodel is brought into the computing area when it is necessary to update the supply status. Expenditures of ammunition and fuel resulting from fire and movement decisions are posted against the basic loads of the primary elements concerned. Operation of the Supply Submodel consists of scrutiny of the on-hand quantity of supplies, placing of requisitions to bring elements with depleted supplies back to their authorized basic loads, and determination of the probable time of receipt of ordered supplies. The Primary Element File is updated in accordance with the results of this process. The Replacement Submodel operates in a similar manner to update the personnel strength of elements whenever replacements are requested and received.

2.3.7 Message Submodel

During the decision and assessment processes, certain situations may arise which will cause the simulated elements to communicate with the players. This is accomplished by posting in the Message Submodel appropriate messages reflecting the situation. The approach taken to the development of messages from the computer is the provision, not of canned sentences, but of a number of coded military phrases in matrix format. The situation sets the abscissas and ordinates of the matrices and combines them to produce the message. At every interval, the Executive Program executes the Message Submodel and the messages are printed out in standard military language for the players.

If a player wishes to reply to the messages or to issue new orders to the elements under his command, he may do so. This process is represented in Chart II by the block on the left marked "Frag Orders from Players." The player gives a standard military fragmentary order which updates the file, and the submodels respond accordingly.

The game is cycled until sufficient data are produced to satisfy the objectives.

2.4 Application of the Model

The CENTAUR game will be capable of testing a tactical Division Plan for infantry, armored, and mechanized units engaged in missions of overland attack, defense, delay, security, and reserve. The game will yield estimates of the number of casualties that would probably be sustained, the amount of ammunition and fuel that would be consumed, and the time that would elapse during execution of the plan under stipulated environments. It will also permit comparison of alternative tactical organizations, supply loads, and manpower strength for relative effectiveness against enemy forces of any stipulated strength.

Since the ratio of game time to real time should be low -- considerably lower than in hand-played games -- it will be possible to replay the game repeatedly in a relatively short period of time. The replays may be accomplished with the same initial input, to increase the level of statistical confidence in the game results, or may involve changes in the assumptions and other factors in order to provide a basis for sensitivity analyses.

The game is, therefore, a technique devised to assist planners in performing timely studies of plans under a variety of different conditions that reflect the uncertainties of the combat situation.

3. ORGANIZATION FOR MODEL DEVELOPMENT

A critical problem facing the model developer is that of organizing his development staff effectively. He must weigh the allowed development time against the need for control. If the model under development is a relatively simple one and the time allowance is adequate, he can keep his staff small and exert close personal control. If, however, his time is limited and the model is complex, the planner must increase the personnel on his staff and apportion the work among them. The resultant division of labor introduces the need for a centralized control system to assure consistency of thought and level of sophistication throughout the development of the different functional areas of the model.

STAG's solution to this organizational problem is a dual structure consisting of a small, rigidly organized control group representing capabilities for both technical supervision and analysis, and a larger, more flexibly organized developmental group from which analytical teams are drawn as needed.

STAG's control group for CENTAUR is composed of one military officer, two Branch Technical Chiefs who are operations research analysts, two mathematicians, and one computer-program analyst. This group has responsibility for establishing the objectives of the simulation, determining the concepts underlying the development of the model, deriving the functional areas that must be studied and embodied as submodels, defining the problems within these functional areas, assigning these areas to the various analytical teams, and then supervising the analysis by these teams. The teams are thereby controlled with respect to sophistication and consistency of thought, insofar as over-all model development is concerned, and yet are given considerable latitude for initiative and imagination in solving the problems in their assigned functional areas. Since the teams are loosely organized, they can be shifted from functional area to functional area as the original problems are solved and new ones arise.

The development group from which the teams are drawn is composed of military analysts, operational analysts, mathematicians, and computer programmers. Each analytical team is organized according to the principle of Blackett's Circus[7] -- i. e., is composed of specialists from the various applicable military and scientific disciplines who approach the problems in concert but from different perspectives. A computer programmer is necessarily part of each team, since in computer-model construction the influence of the programming arts must be felt during the development of each of the functional areas.

Once an analytical team is assigned a functional area, it proceeds unilaterally to develop a submodel to represent that area. The composition of the team lends itself to precision during this unilateral development. The military analysts study the submodel problems and describe them in military terms; the operational analysts translate the military description into mathematical terms; and the computer programmers then translate the mathematical description into computer terminology. The close working relationship of the team members enables them to avoid distortions in basic content as the problem undergoes translation from the language of one discipline to that of another.

As a further control device, the analytical teams are grouped functionally into two branches, one centering around the combat area and the other around the combat support area. Each branch contains about eight military and civilian analysts and is headed by a military chief, who is responsible for the over-all operation of the branch, and a technical chief, who concentrates on the analyses performed by the teams. To assure coordination of the technical development with the control group, the technical chiefs are members of the control group.

Unilateral development of the various functional areas would inevitably introduce variations in level of sophistication if there were no provision for coordinating the work of the analytical teams. Such coordination is the responsibility of the control group, which exerts its unifying influence in three principal ways:

(1) It constructs the Executive Program, which provides the structural base for the operations within the computer.

(2) It controls the interfaces between submodels through control of the required inputs and outputs.

The inputs to a submodel are the parameters on which the solutions to the problems represented by the submodel are constructed. The solutions are the outputs of the submodel.

Since the Executive Program controls the functions of the submodels in a cyclic manner, the Control Group, when establishing the functional area problems, must so define the submodel inputs and outputs that the output of one submodel determines the input of the next submodel. The inputs and outputs can therefore be considered interfacing parameters, control of which assists in assuring consistency of thought throughout the model.

(3) It controls the nature and quantity of the items placed in the game files. Since the files constitute the parameters on which the game is constructed, the submodel developer can neither add nor delete detail without to some extent altering the nature of these parameters. Control of the files is therefore effective control of the level of sophistication of the various submodels.

When the mixed-team approach is used, it becomes vital to evolve a common language so that specialists from the different disciplines can communicate and arrive at a common understanding. The ability to communicate across interdisciplinary lines is gained only through industry, experience, and patience. The control group's knowledge of the ability of staff personnel to communicate with representatives from other disciplines thus becomes another means of controlling the development of the model as a whole.

Simulation of a complicated military situation is an exacting task which depends upon the ability and vision of the development staff and the state of the art with respect to computer technology. Even more heavily, however, it depends on the ability of the planner to develop an organization that will carry through from the initial concept to final documentation of the war game.

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